MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

EOP3036 – FABRICATION AND PACKAGING TECHNOLOGY

(OPE)

7 MARCH 2016
2:30 p.m. - 4:30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 5 pages including cover page with 4 questions only.
2. Attempt **ALL FOUR** questions and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) Liquid phase epitaxy (LPE) is one of the growth techniques that can be used to grow an epitaxial layer on a semiconductor wafer.

(i) Describe how a 5 μm thick *p*-type silicon epitaxial layer is grown on top of a *n*-type silicon substrate by using the LPE technique to form a simple *pn*-junction.

[6 marks]

(ii) Justify if a 50 nm thick epitaxial layer is suitable to be grown by the LPE technique.

[3 marks]

(iii) Name two other epitaxial growth techniques that can be used to grow a 50 nm thick epitaxial layer.

[3 marks]

(b) In order to grow an aluminium-doped silicon wafer, 4 g of aluminium is mixed with 50 g of silicon in the crucible of a Czochralski crystal-growth system. The mixture is heated up and all aluminium atoms are dissolved into the silicon molten. Given that the mass density of the silicon is 2.53 gcm^{-3}, the atomic weight of aluminium is 26.982 a.m.u. and the equilibrium segregation coefficient k for aluminium is 0.002.

(i) Calculate the concentration of aluminium atoms in the silicon molten.

[6 marks]

(ii) Assuming that all aluminium dopants are ionised and the carrier mobility is $\mu = 340\ cm^2V^{-1}s^{-1}$, calculate the conductivity of the silicon wafer taken at the initial growth stage of the silicon ingot.

[4 marks]

(iii) Is the resulted silicon wafer an *n*-type or *p*-type semiconductor? Justify your answer.

[3 marks]

Question 2

(a) Describe the differences between positive and negative photoresists when they are exposed to ultra-violet light source and immersed in photoresist developer.

[4 marks]

(b) White light emitting diode (LED) is one of the promising candidates for realisation of solid state lighting. White LEDs could be fabricated by coating a phosphor layer on top of the LED dies before the encapsulation process is carried out. **Figure 2(b)** shows the structure of LED dies fabricated based on gallium-nitrate (GaN) material. The size of each die is 5 mm (diameter).

Continued.....

With suitable schematic diagrams, propose the required fabrication processes to realise the LED dies. Label your schematic diagrams and process flow clearly and give a short description for each of the proposed process. You are not required to include the deposition of phosphor layer in your answer.

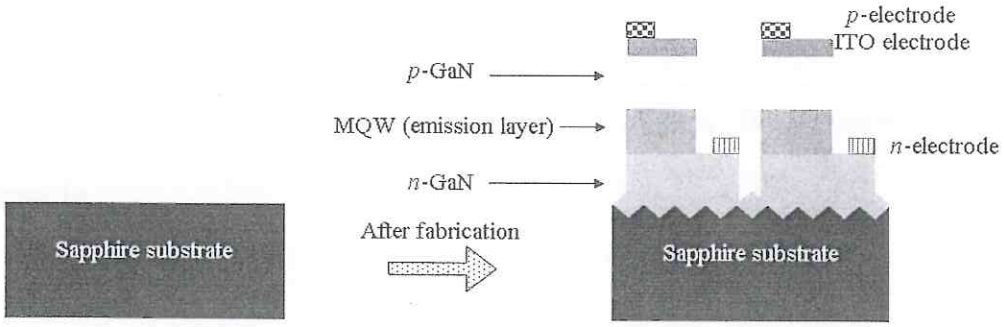

Figure 2(b)

[5×3=15 marks]

(c) In order to produce reliable high-power light emitting diode (LED), few challenges such as the (i) **light extraction**, (ii) **thermal yellowing** and (iii) **ultra-violet yellowing** need to be addressed properly during the packaging process. Describe briefly the problem associated with each challenge and suggest ONE possible solution for each challenge.

[3×2=6 marks]

Question 3

(a) Plasma-activated chemical vapor deposition (PCVD) technique could be used to grow the preform required for the production of graded-index multimode optical fibre.

(i) Draw and label the important components needed in the PCVD technique.

[6 marks]

(ii) Explain the operation principle of the PCVD technique.

[6 marks]

(iii) Is the PCVD technique suitable for the production of graded-index multimode optical fibre? Justify your answer.

[2 marks]

Continued.....

(b) Silica-based optical fibre is commonly used in the optical communication network as the medium for light transmission. The outside vapour phase oxidation (OVPO) is used as the fabrication technique to realise the preform of the optical fibre.

(i) Describe the operation principle of the OVPO technique.

[6 marks]

(ii) Give TWO drawbacks of the OVPO technique.

[4 marks]

(iii) Propose ONE method that is able to overcome the drawbacks of this technique.

[1 mark]

Question 4

(a) Optical fibre buffering is a fibre cabling step that is used to protect the optical fibre from the microbending losses and also ingress of water. Discuss how the following optical fibre buffering techniques provide protection for optical fibres.

(i) Tight buffer jacket.

[4 marks]

(ii) Loose tube buffer jacket.

[5 marks]

(b) Delta Optical Fibre Limited is entrusted by the Malaysia government to design and construct a high-bandwidth long-haul optical communication system in Malaysia so that all the government-owned data centres could be linked together for data sharing purpose. Some of the specifications of the optical communication system are listed in the table below.

Criteria	**Specification**
Operating length	6000 km
Data rate transmission per channel	40 Gbit/s
Attenuation	Less or equal than 0.25 dB/km
Light source	Distributed feedback laser

Based on the given specifications,

(i) Propose one suitable optical fibre, and

[1 marks]

justify your answer according to the following considerations:

(ii) Structure of the optical fibre,

[3 marks]

(iii) Material choice for the optical fibre, and

[3 marks]

(iv) Transmission wavelength.

[3 marks]

Continued.....

(c) **Figure 4(c)** shows the schematic diagram of a cross section of a fibre cable. State the names of the components labeled from 1 to 3 and describe briefly their functionalities.

[3×2=6 marks]

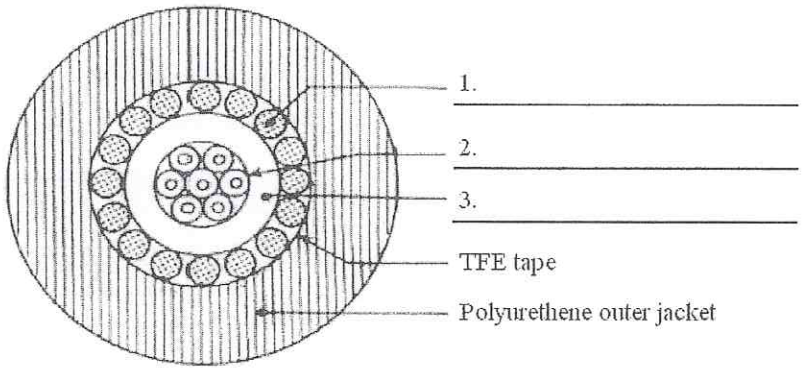

Figure 4(c)

List of constants
Electronic charge, $e = 1.60 \times 10^{-19}$ C
Avogadro number, $N_A = 6.02 \times 10^{23}$ atoms

End of Paper